REMOTE INTERROGATION-INFORMATION EXCHANGE SYSTEM: A TECHNICALLY VIABLE AID TO NAVAL COMMAND AND CONTROL

John Conrad Lawlor

NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

REMOTE INTERROGATION-INFORMATION EXCHANGE SYSTEM: A TECHNICALLY VIABLE AID TO NAVAL COMMAND AND CONTROL

by

John Conrad Lawlor, Jr.

Thesis Advisor: J. P. Hynes

March 1973

Remote Interrogation Information Exchange System:
A Technically Viable Aid to Naval Command and Control

by

John Conrad Lawlor, Jr.
Lieutenant, United States Navy
B.S., United States Naval Academy, 1967

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
March 1973

ABSTRACT

The concept of accessing a data base and EDP equipment located ashore from ships at sea is presented as a complete system entitled Remote Interrogation Information Exchange System (RIIXS). The system contains the following elements: a data base located ashore; an input/output terminal located aboard ship; and a digital data link, provided by FLTSATCOM, connecting the two. RIIXS is designed to supply the fleet commander with operational information vital to command and control in addition to providing command mobility and rapid command assumption. RIIXS is evaluated on the following criteria: reliability; survivability; maintainability; personnel manning; data transmission rates; dollar cost resource allocation; and contribution to command and control. RIIXS is shown to be vastly superior to a similar system located aboard ship.

TABLE OF CONTENTS

TABLE OF ABBREVIATIONS

ADP	Automatic Data Processing
bps	bits per second
CDCC	Central Data Control Center
EDP	Electronic Data Processing
FLTSATCOM	Fleet Satellite Communication (System)
HF	High Frequency (3-30 MHz)
IFDS	Integrated Flag Data System
NFC	Numbered Fleet Commander
NFCIT	Numbered Fleet Commander Interrogation Terminal
NTDS	Navy Tactical Data System
OIC	Officer-in-Charge
RIIXS	Remote Interrogation Information Exchange System

I. INTRODUCTION

Communications have always played an important part in military operations. Both strategic planning and tactical operations have relied very heavily on communications in the past 200 years of world history. This point is valid whether in regard to breaking the Japanese cryptic communications code of World War II or the present system of communications stations around the world.

The importance of any communications system is its ability to exchange information between different points around the world; this information assists the military commander in making decisions. A military commander has "command" by virtue of his rank or position. However, he can have control of a situation only when he has the fundamental information governing that situation. The better information he has, the greater are his chances of effectively controlling the situation. Also, if the information that he has is valuable, and his enemy does not know that he has it, then the military commander can have even greater control over the situation. Valuable information is an integral part of "Command and Control" in the military.

So far the term "valuable information" has been used in the discussion without any definition. This is because information or intelligence means many things to many military commanders. Therefore, the author has elected to

define the term "valuable information" to include any or all of the following qualities:

> Completeness of the information.
> Security of the information.
> Timeliness of the information.
> Accuracy of the information.
> Intelligence on enemy forces.
> Intelligence on neutral forces.
> Intelligence on own forces.

Since valuable information is an integral part of "Command and Control," how is it transmitted to the military commander? Throughout military history the answer has been some type of "communications system." In the past, many unsophisticated systems have existed: runners, smoke signals, gunshots, lights, semaphore, flaghoists, and HF radio. Some of the examples may seem obsolete, but at one time each system was "state-of-the-art," and was able to get valuable information to the military commander.

An accurate definition of a communications system in terms of military applications would be: "An information exchange system that is vital to Command and Control." How many military commanders think of our current communication system as an information exchange system? Probably not very many. How many would look at a telephone and think, "information exchange system"? The point here is that for too long military commanders in the Navy have

looked at a communications system and all they saw was a communication system. They have failed to realize that "good communications" equal "good exchanges of valuable information." They have failed to realize that a reliable exchange of information is vital to command and control! If the information is not valuable, then there is little reason to exchange it.

It is hard to get people to change their attitudes or philosophy without a great deal of time and directed effort. This is certainly true when it comes to improving and automating naval communications. In order to sell a bill of goods, the buyer must first be educated to the importance of the goods. A step in the right direction would be to begin calling the Naval Communications System by a more appropriate name. The Naval Information Exchange System to Support Command and Control appears to be a more accurate title. The new phraseology appears even more accurate when applied to the Navy's satellite program. Rather than call it the Fleet Satellite Communication System, call it the Fleet Information Exchange System. In reality, a satellite does not communicate, but rather it exchanges information from one point to another.

What is now called the Fleet Satellite Communications System is really the most sophisticated information exchange system yet proposed to aid command and control at sea. Satellites have tremendous information exchange capabilities

and thus they have tremendous command and control capability if naval commanders are willing to take advantage of the situation.

The purpose of this thesis is to narrow these capabilities down to one area. The area under consideration is the information exchange system directly related to fleet commanders at sea. The current command and control philosophy contends that a fleet commander should be located with the fleet at sea on a capital ship. In addition, the fleet commander is given a large staff and limited EDP equipment to provide him with valuable information for decision making. This concept is not being questioned, but it should be noted that when new equipment is brought aboard a ship, certain other equipment must be removed. In certain instances in the past, this has meant the removal of ship's armament and crew's living spaces.

Normally there is only one flag ship in a numbered fleet. If this ship sustains battle damage and is lost to the fleet commander, the Admiral loses the use of his information exchange system and so does the fleet. That is to say, a numbered fleet can lose its valuable decision making assets without losing its commander. The loss of these assets would imply a tremendous loss in command and control effectiveness.

During the age of sail, a fleet commander was primarily concerned with what he could see from horizon to horizon.

If he could not see it, it did not bother him. This situation existed because once a ship was sighted on the horizon, it might take as much as half a day of sailing to get close enough for engagement. Because of the nature of the weapons involved and the time span taken to employ them, a fleet commander had ample opportunity (often measured in hours) to appraise his enemy and take the appropriate action.

Admiral Nelson realized the importance of communications to command and control even when the movement of his fleet depended on the wind, and the range of his cannon was not much more than a mile. He modified Britain's elementary flaghoist signaling system and parleyed with his captains prior to major sea battles [Ref. 11]. He realized the importance of command and control in the thick of a major sea battle and took great pains to communicate his battle objective to his captains prior to a major sea battle. The important point to remember here is that Nelson used and depended on the most reliable state-of-the-art communications available to him at the time for success at sea. His most remembered flaghoist was the one he raised while engaging the French and Spanish at the Battle of Trafalgar in 1805: "England expects that every man will do his duty." [Ref. 11].

Little had changed in the way of communications from Nelson's era up to the time of World War II except for the advent of radio, flashing light, and a more sophisticated flaghoist code. World War II saw the development and

deployment of radar for the first time in naval warfare. Radar expanded a sea commander's area of immediate concern to a distance slightly over the horizon. Considering the relatively slow speed of attacking aircraft (200 knots) and attacking ships (30 knots), the fleet commander was still able to prepare his defenses after the enemy was detected. Preparation time was often measured in minutes. Preparation was accomplished by disseminating valuable information to his own forces about the enemy, the most basic of which was the speed, altitude, direction, and number of enemy aircraft or ships. But still a fleet commander's area of immediate concern could be measured by a few hundred miles.

At that time, communications for command and control was still a very limited concept. In fact, communications had a major impact on the outcome of World War II in that the enemy's own communications were used against him. The breaking of the Japanese cryptic code early in the war had monumental effects on the outcome of the war. Two very dramatic examples of these effects were: (1) The very successful sea battle at Midway where the Japanese lost four aircraft carriers and a large number of their veteran carrier pilots. (2) The second example was the shooting down of the airplane that contained the senior Japanese admiral at the time, Admiral Yamamoto, by several Army Air Corps pilots early in the war. The loss to the Japanese

was equivalent to the loss of Admiral Chester W. Nimitz to the United States had that occurred.

During World War II, the importance of communications grew, but its importance to command and control was still a very limited viewpoint. The quality and reliability of HF radio left a great deal to be desired in the eyes of many fleet commanders. At times it was even considered a luxury, not to be depended upon, and certainly not good enough to base the survivability of a fleet on.

The weapons of modern warfare have changed drastically since World War II. These weapons have placed a tremendous burden on the fleet commander to maintain the survivability and combat readiness of his fleet. His area of immediate concern is no longer just over the horizon. His area of concern is now the whole ocean in which he sails and the countries that border it. The threat to his force is no longer limited to snorkeling submarines a few thousand yards away or 200-knot aircraft a couple of hundred miles away. The enemy may be a whole continent away; he can track the fleet's movements with surveillance satellites, and launch ICBM's with nuclear warheads at a task force. It is possible for the enemy to strike without ever being detected because of "over the horizon capability" weapons. A fleet commander may have a warning of only a few seconds prior to an enemy attack. Such short notice is not enough time to prepare a defense, therefore, necessitating constant preparedness. In addition, the number of

independent countries in the world has more than doubled since the beginning of World War II, adding greatly to the number of special political situations that a fleet commander must be aware of.

The sphere of influence and the number of special requirements that a fleet commander is responsible for is infinitely greater now than ever before. Neither he nor his staff is capable of committing to memory all the items of information that he is responsible for. Therefore, some time of recording and filing system must be maintained to aid the fleet commander in making decisions. Additionally, the file system must be updated periodically, and easily accessible for retrieval of information.

It should be apparent that the number of present-day special situations dictates that a fleet commander needs a staff and some type of file system to accomplish his job effectively. The next question that arises is where to place such a file system. Historically, the file system has always been placed aboard ship because of the ease and timeliness with which information could be retrieved. Recently though, these files have grown so large and complicated that costly EDP equipment is required to do the job effectively. As an example, Integrated Flag Data System (IFDS) was placed aboard the <u>USS Providence</u> for test and evaluation purposes. IFDS alone required a staff of about 40 specially trained personnel, several million dollars worth of computers, and display equipment, as well as a substantial part of the ship's combat spaces.

The decision to place IFDS aboard ships was based primarily on the fact that such a location provided the greatest reliability of getting valuable information from the file system to the fleet commander to use in making decisions. Updating of the files still relied on HF radio and in-port periods. The accuracy and, therefore, the usefulness of IFDS relies on the ability to update data files with current information. HF radio offers timeliness compared to in-port periods but data rates and accuracy are poor, even under optimum conditions. In-port periods, on the other hand, offer improved accuracy and increased data transfer rates, but timeliness is sacrificed.

With the introduction of Fleet Satellite Communications (FLTSATCOM) to the Naval Communications System in 1975, a reliable high-speed data transfer system will be available for use in updating file systems on a real-time basis. But before that idea is pursued in any great detail, the ramifications of such a decision need to be analyzed.

First, EDP-type file systems can be placed only on large ships such as CVA's, LPH's, LHA's, LCC's and CLG's due to the space and people required for the equipment. By 1975, all the cruisers in the Navy's inventory will be more than 20 years old. Can it be justifued to place a multi-million dollar EDP-type file system on a ship already more than 20 years old which must support the system for another 10 years?

Secondly, the placement of a file system on a ship makes that ship an extremely high-value target to the enemy. The high-value target does not refer to the fleet commander aboard, but rather to the highly specialized equipment aboard. The objective of the enemy will be to eliminate that equipment from the fleet and not necessarily eliminate the commander.

To bring this point to light we can recall a very important part of American history. During the War of 1812, Commodore Perry was given the task of defending the Great Lakes against British attack. In 1813, the British did attack and Commodore Perry resisted the attack with a small fleet of sailing vessels. During the course of the battle, his flagship, the Lawrence, was completely disabled. Perry was able to escape with his "colors," row to another ship in his fleet and successfully carry on the battle. After the battle, he sent his now famous message, "We have met the enemy and they are ours..." [Ref. 11]. By soundly defeating the British on Lake Erie in 1913, Perry was able to protect the United States northern flank for the rest of the war and this fact contributed significantly to the outcome of the war.

Back in 1813, command and control was represented by the fleet commander and his "colors." Today, and more so in the future, command and control will rely heavily on elaborate EDP and communication systems. If Commodore Perry

had been relying on an EDP file system, he would not have been able to carry his primary command and control system to another ship in the thick of battle and probably would have lost the battle.

If placing the file system afloat has these significant drawbacks, where should it be placed? The obvious alternative is to place the system ashore at a secure naval station; this alternative provides many significant advantages which can be realized in all areas of operations. A high-speed data link between the fleet commander at sea and the shore station can be used to communicate accurate information to the fleet commander at sea in a timely manner. A dedicated data channel in a synchronous communication satellite located between the two points could provide such a high-speed data link.

To be able to get information from a computer, the user must access the computer through some type of input/output terminal. This applies whether the user is standing next to the computer or whether the computer is a thousand miles away. In any case, a reliable communication path must exist between the users' terminal and the computer. With the introduction of the FLTSATCOM system in 1975, such a path will exist. This thesis will examine the concept of interrogating computer data files from various remote terminals around the world. Such a concept is called a Remote Interrogation Information Exchange System (RIIXS) [Ref. 15]. This idea is not a new one, but to date, no great

emphasis has been placed on this idea by the Navy. The objective of this thesis is to develop and expand the concept of Remote Interrogation Information Exchange and to propose a system that could be implemented as a subsystem to the Navy's FLTSATCOM program.

II. REMOTE INTERROGATION INFORMATION EXCHANGE SYSTEM DESCRIPTION

A. INTRODUCTION

Remote Interrogation Information Exchange System (RIIXS) is a command and control data processing system designed to support numbered fleet commanders (NFC's), at sea or ashore, during the 1975-1985 time span. RIIXS is a concept based on the information exchange capabilities of the Navy's FLTSATCOM program. Since RIIXS is primarily a concept of information exchange between two different points in the world, it is flexible to change and can meet various requirements as set forth by the NFC's. Through the use of modern EDP procedures and the high-speed data links provided by FLTSATCOM, it will be possible for a fleet commander to place his bulk files ashore and access them through remote terminals. This is the concept of interrogating informational files from remote terminals which will be called "RIIXS" throughout the remainder of the thesis.

B. SYSTEM DESCRIPTION

RIIXS can be considered divided into three main areas: (1) the fleet commander's interrogating terminals and display equipment; (2) the computers ashore with their bulk data files; (3) the transmission path between the two, through which the information will be exchanged. Each one of these areas will be discussed briefly at this time.

Details will be brief due to the fact that only the capability for certain families of equipment is presented without regard to specific types. Certain equipment will be common to all RIIXS users while other types may be unique to the various NFC's.

1. <u>Central Data Control Center</u>

The author has elected to call the shore aspect of RIIXS the Central Data Control Center (CDCC). Optimum placement of the control center should be at or near a FLTSATCOM ground terminal. In this way, information can be relayed quickly, reliably, and in large volumes to the NFC via the FLTSATCOM ground terminal. Secondly, the control center should be located in an area where the NFC has some sphere of influence. Considering the construction of just two CDCC's, optimum placements could be in NCS Honolulu and NCS Norfolk.

The heart of the control center will be a computer designed to store and retrieve large volumes of data located in files. In addition to the CPU, a large array of peripheral storage equipment will be required. Included in this equipment will be magnetic tape, disc, and drum files. Particular use will depend on the frequency that information changes within the files and the frequency with which the NFC will require the information. (See Figure 1.)

Additionally, the CDCC will contain a number of visual display units and high-speed printers with which inputs and outputs can be monitored. Inputs and outputs

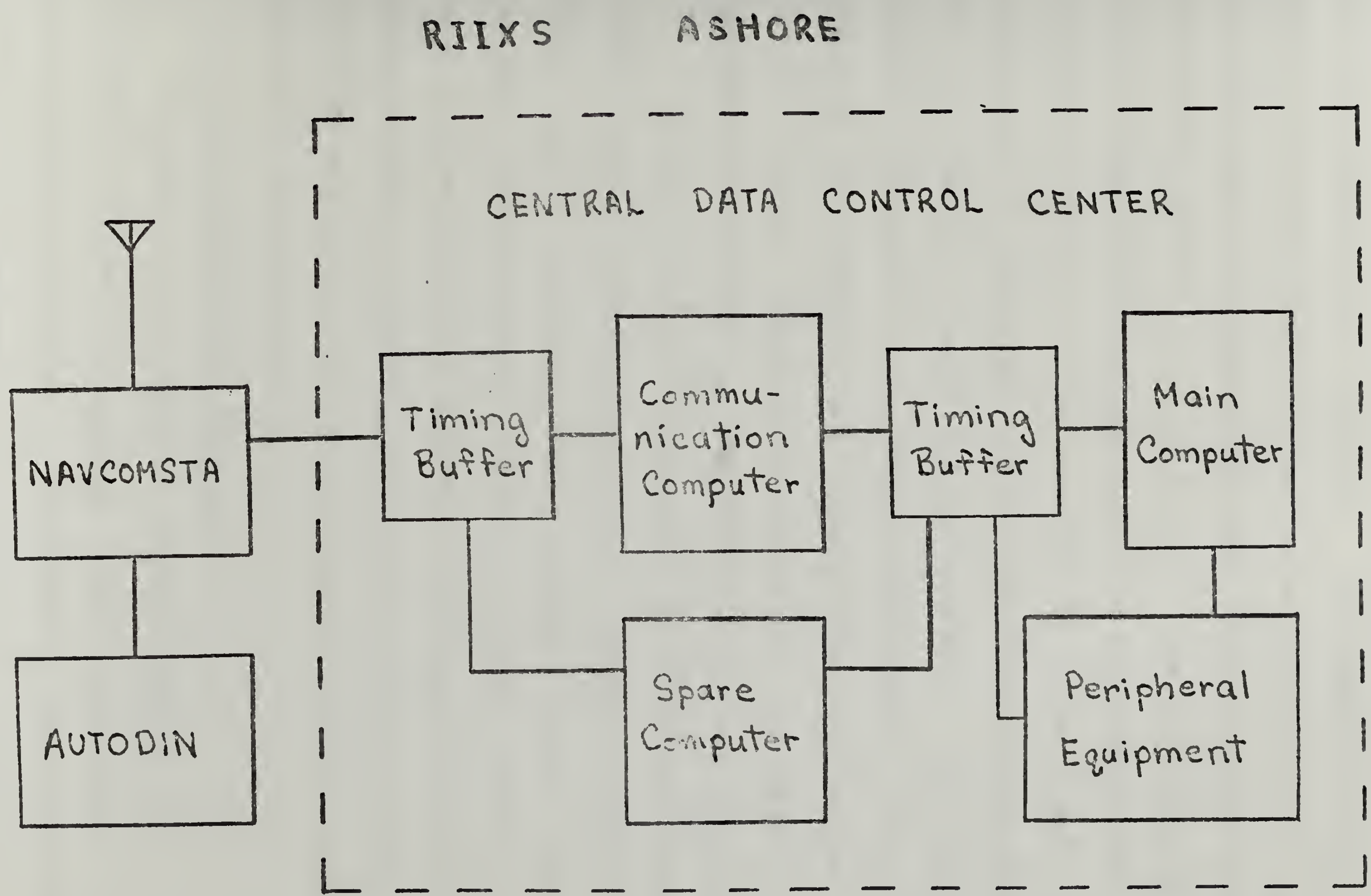

RIIXS ASHORE
CENTRAL DATA CONTROL CENTER
NAVCOMSTA
AUTODIN
Timing Buffer
Commu-nication Computer
Timing Buffer
Main Computer
Spare Computer
Peripheral Equipment

Figure 1

to the control center will pass through a specially designed communications computer. The communications computer will be separated from the main CPU by some type of buffer which will permit the main CPU to operate without becoming "input or output bound." The main purpose of the communications computer will be to document and forward all requests to the main CPU in a timely and orderly fashion. The main CPU will then answer the requests from the information contained in its files. Once the information is retrieved, it is dumped into a buffer. The communications computer then retrieves the information from this buffer, completes documentation, and sends the information to the NFC via the FLTSATCOM ground terminal.

The CDCC should be maintained by personnel trained in the computer-communications field. Since the CDCC is ashore, civilian personnel may be employed in many areas. Also, much of the equipment could be standard manufacture design without expensive MILSPECS. The senior officer in the CDCC should be knowledgeable in the area of computer operations and should also be assigned as a member of the NFC's staff in a detached status.

2. NFC Interrogation Terminal

The NFC's Interrogation Terminal (NFCIT) is basically an information exchange subsystem terminal, located in one of the ship's compartments. On designated flagships the compartment will be specially designed to accommodate all necessary equipment and to facilitate the

display of requested information for the NFC. Among the more important pieces of equipment required will be several visual display units that can produce both graphics and alphanumeric information on their screens. At least one high speed printer will be needed to print out alphanumeric information received from the CDCC. In addition, it is recommended that a minicomputer be available to supply a limited memory capability to provide for emergency situations and also reduce redundant queries to the CDCC. Storage capacity can be located in the NFCIT or maintained in another compartment. (See Figure 2.)

Information in and out of the NFCIT will be in digital form and be transmitted to the ship's communication center by coaxial cable. Outbound information will be passed through the appropriate modems and basic FLTSATCOM transmit/receive equipment. Once the information leaves the NFCIT in proper digital format, responsibility for accurate and timely transmission of the data to the proper CDCC rests with the FLTSATCOM Information Exchange Systems.

3. Information Exchange Path

The path through space that the information will be exchanged between the CDCC and the NFCIT is really the simplest and most basic section of RIIXS. The successful operation of the information exchange path relies completely on the operation of the FLTSATCOM system as outlined in SOR 32-18 (July 1972). This is because the alphanumeric data required

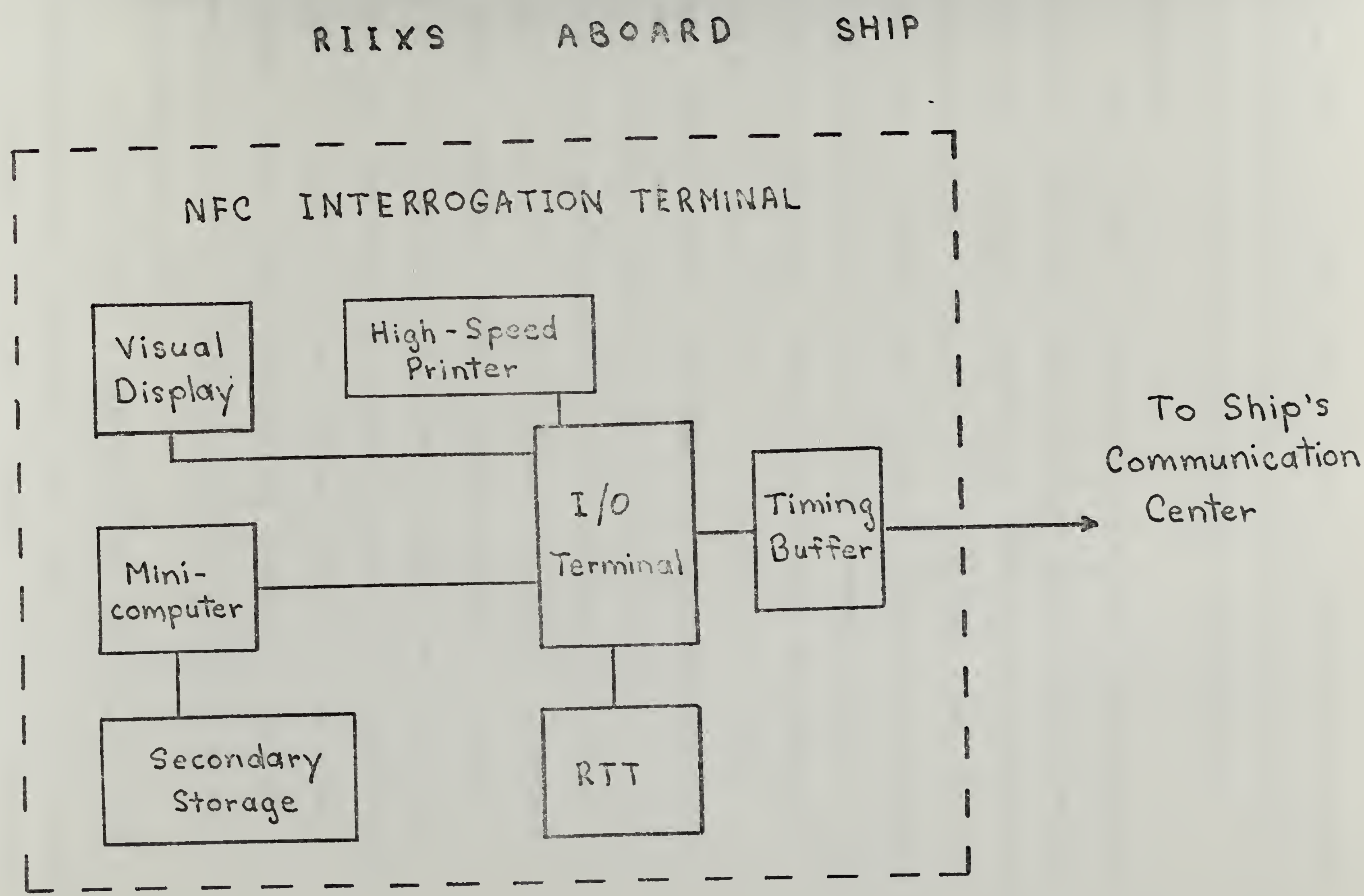
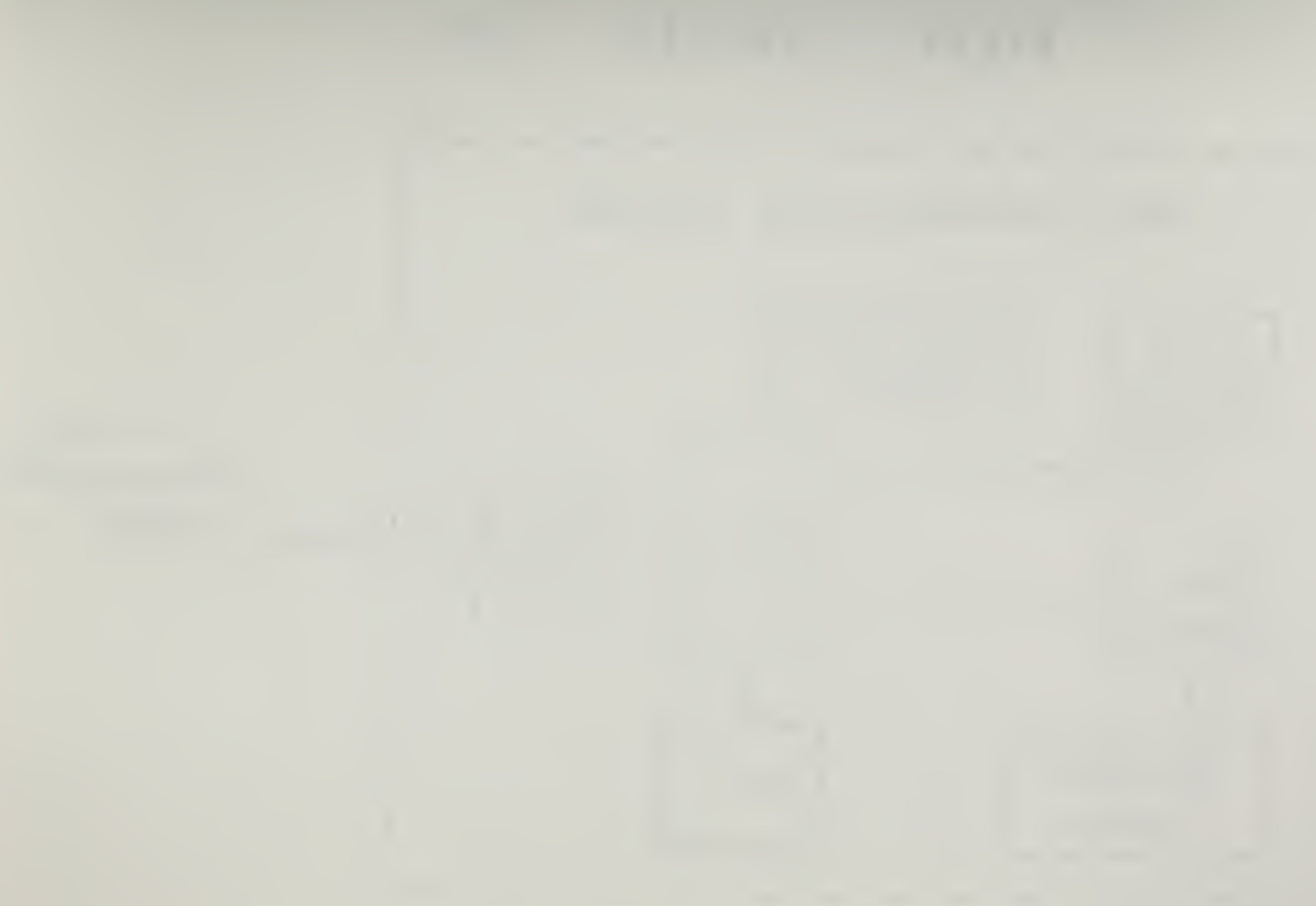

RIIXS ABOARD SHIP
NFC INTERROGATION TERMINAL
Visual Display
High-Speed Printer
I/O Terminal
Timing Buffer
Mini-computer
Secondary Storage
RTT
To Ship's Communication Center

Figure 2



by the NFC in the time span, quantity, and quality required can be supplied only by digital transmissions in the UHF and SHF frequency spectrum via synchronous communication satellites.

UHF and SHF are basically line-of-sight frequencies that have a very high data carrying capacity when compared to HF radio. The main drawback to them is that transmission characteristics are basically in a straight line. This means that the receiver and transmitter have to be capable of seeing each other for successful communications to occur. It is anticipated that there will be very few occasions when the CDCC and NFCIT are in a position for line-of-sight communication. Therefore, a synchronous satellite (or satellites) located approximately 22,500 miles above the earth is needed to act as a relay vehicle between two points on earth. (See Figure 3.) At this altitude, a single satellite can cover approximately one-third of the Earth's surface for line-of-sight communications. Three such satellites can provide world-wide communication capability between any two points except for the polar regions. This basic communication capability will be available to the RIIXS concept with the implementation of FLTSATCOM in 1975.

The data to be transferred between the CDCC and the NFCIT will be in digital form. Both still-frame graphics and alphanumeric text will be capable of being transmitted at 2400 bps [Ref. 15]. Since bandwidth will be at a premium

RIIXS COMMUNICATION PATH

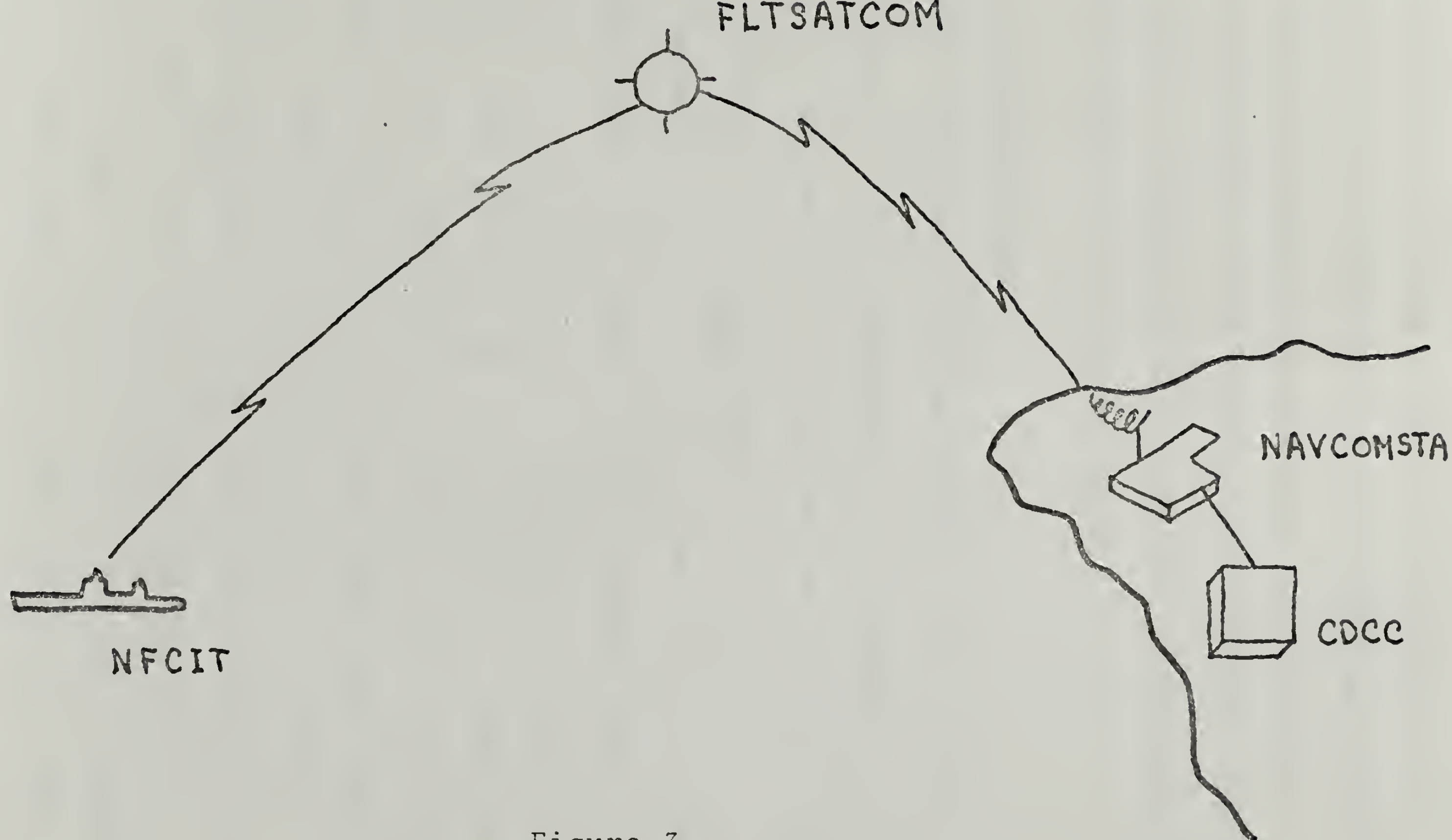


Figure 3

in the satellite, RIIXS will operate in a time sharing mode. This means that at some instant in time the NFC cannot use RIIXS due to user saturation of the satellite's bandwidth. This time span of inoperation is considered small and tolerable for system operation. Once the NFC is able to secure a channel of the satellite's frequency he cannot be pre-empted by any other user.

C. PRIMARY RIIXS FUNCTIONS

As has been stated earlier, the ability for a fleet commander to make decisions concerning fleet operations and national security depends on the information available to him. Communicating proper information to an NFC is a critical command and control function along with the proper format and timeliness with which the NFC receives the information. As an example: If an NFC wants to know the location of his fleet oilers, he does not want a complete file listing all ship locations; he wants a one- or two-page printout naming the ships concerned and their last reported location. If he wants to know whether or not a certain ship has an ASW capability, he does not want a whole file listing every ship in the fleet with an ASW capability; rather he wants a single printout naming the ship, stating whether it has an ASW capability or not, and if so, the weapon systems aboard.

The responsibility for the timeliness and accuracy of information will hinge on three major factors: (1) original

arrangement of the files at the CDCC; (2) type of EDP equipment used for correlating the information; (3) an officer in charge of the CDCC capable of validating the information being sent out in response to NFCIT queries.

RIIXS performs three main functions in supporting the NFC. These are: (1) Information collection and maintenance; (2) Information retrieval and correlation; (3) Information display.

Information collection and maintenance: is responsible for the collection, validation, and recording of information in the proper files. Validating and updating information already recorded in files on a periodic basis is considered a prime responsibility of maintenance.

Information retrieval and correlation: is responsible for retrieving the information germane to NFCIT queries and correlating that information down to the smallest possible format. The officer in charge of the CDCC will be of prime importance to the success of RIIXS. This is a major reason why the officer in charge of the CDCC should be a staff member of the NFC concerned.

Information display: can be in either of two forms: visual display or high-speed printout. The NFCIT should be capable of displaying the same information in either format. Additionally, the CDCC will have duplicate display equipment as that in the NFCIT. In this way, it will be possible for the OIC of the CDCC to monitor all information transmitted to the NFC in the exact same format.

D. RIIXS DATA BASE

The information contained and the way the information is organized within the data base is of prime importance to the success of RIIXS. The primary objective of the CDCC is the storage and organization of information into a data base that can respond quickly and accurately to queries from the NFCIT. The author sees three main areas of information that should be contained in the data base: general and administrative type information; information on NFC's operational forces; and information on other than NFC's own forces. (The latter has been historically called intelligence.)

1. General and Administrative Type Information

Personnel records to include pay and leave accounting data.

Visitor clearance, including VIP's and engineering consultants.

Index of Navy notices and recent directives.

Oceanographic and meteorological data.

EMCON contingency plans.

Electronic and acoustic signature files on ships and individual equipment, including both foreign and U.S. fleet units.

Requirements of major treaties with nations in the NFC's operating area.

Storage of battle contingency plans.

2. NFC Operational Forces

Mission capabilities and limitations of individual fleet units to include, but not limited to, armament, speed, range, and endurance.

Identification and location of all fleet units at any given time or projected time in the future.

Ability to determine individual fleet unit capability for continued operations after sustaining battle damage.

Special reports of fleet units such as OPSTAT, FORSTAT, MOVREP's, CASREPT's, SITREP's, etc.

Location and status of all support elements under jurisdiction of the NFC.

Ability to determine the most appropriate unit for future task assignments based on location and capabilities of all fleet units.

3. Intelligence on Other Forces in the NFC's Operating Area

Location, identification, and capabilities of all air and naval forces to include friendly, unfriendly, and neutral units in the operational area.

Foreign air and naval orders of battle.

Direction from which hostile action is most likely to occur.

Special files on geographic and political happenings that are classified as "sensitive situations."

The above list of requirements is not designed to be the total informational package contained by the CDCC, but should be considered general guidelines. The three main information headings, Administrative, Operational, and Intelligence, should be considered a good beginning to the organization of the CDCC data as direct support to the NFC.

E. RIIXS EQUIPMENT

During normal operations, RIIXS may be spread out over several thousand miles. Therefore, the equipment must be

classified by geographic location as well as operational use. Basically RIIXS is a computer-oriented data base serving a designated remote terminal through a communication link; and because of this the equipment will be looked at from this vantage point.

1. Communication Link

The communication link is the means with which information is exchanged back and forth between the data base and the designated terminal. The actual link is to be provided by FLTSATCOM's system of satellites, ground stations, and terminal equipment aboard ships. All information will be transmitted in digital form as specified by FLTSATCOM requirements. This digital information will originate from the NFCIT, be directed to the ship's communication spaces, pass through the necessary buffers and modems and then transmitted to the proper FLTSATCOM satellite. This satellite will then relay the information to the proper FLTSATCOM ground station, through its buffers and modems, and then transmit it to the CDCC. The communication link just described (from NFCIT to CDCC) will rely entirely on the equipment in the FLTSATCOM system as designated in SOR 32-98 dated July 1972.

2. Central Data Control Center

The Central Data Control Center (CDCC) is the data base which must supply a designated terminal with designated information. The volume and type of information that must be supplied in a quick response mode necessitates the use

of modern EDP equipment. It is envisioned that three computers will be necessary. As was mentioned earlier, a separate communications computer is needed to handle message traffic. A main computer is needed for the actual processing, information retrieval, and data base updating. A third computer should be available as a back-up and be capable of taking over in the event of a failure in either one or both of the two primary computers. The main CPU's should be designed to work in a time sharing mode either independently or in unison.

In addition to computer hardware, various peripheral equipment will be necessary for successful operations. The exact model types and numbers are such that they should be specified at a high command level. Nevertheless, it is possible to generalize the type of equipment needed to fulfill the mission and it is listed below.

Magnetic tape units
Disc file units
Input/output terminals
Temporary storage buffers
Card punch machines
Card readers
Card sorters/verifiers
Paper tape units
High-speed printers
System monitor console
Visual display units
Teletype printers
Microfilm/microfiche

3. Numbered Fleet Commander Interrogation Terminal

The Numbered Fleet Commander Interrogation Terminal (NFCIT) is to be considered a remote terminal with the sole purpose of supporting the NFC with command and control information. Therefore, the equipment necessary to fulfill this requirement can be reduced to basic input/output terminals and various display units. Additionally, a small computer with limited storage capacity will be required. The storage capability could be availabe in several forms: magnetic core, tape or disc.

The input/output terminals will be operating at 2400 bps so it is anticipated that not more than two, with one as a back-up will be needed. Display units could include any combination of teletype, high-speed printers, and visual display units. The following equipment should be specified as a requirement of the NFCIT:

Minicomputer
Limited storage capability
Visual display unit
High-speed printer
Teletype units
Input/output terminals
Modems

Scheduling and sequencing of message inputs will be a manual process. Also, all message queries will be assigned a precedence in accordance with current naval directives. The NFCIT ship's communication center will then process the message queries based on the assigned precedence.

[illegible]

III. RIIXS EVALUATION CRITERIA

A. INTRODUCTION

The true value of a system to the Navy should be measured by a set of standards of some type. The author has chosen seven basic subject areas to use as criteria for evaluating RIIXS. The seven areas are: reliability, survivability, maintainability, personnel manning, data transmission rates, dollar cost resource allocation, and contribution to command and control.

The use of satellites for information exchange purposes is new to the Navy and it is still relatively new to civilian organizations, such as COMSAT. This newness factor makes it extremely difficult to estimate concrete numbers or dollar figures for evaluation purposes. Even if numbers were calculated, they could be misleading because of what was and what was not included. A trite but often used expression may be appropriate at this time: "Figures don't lie, but liars figure."

As an example, assume that it is necessary to estimate the annual costs involved in operating a naval communication station in the continental United States (CONUS). Some of the more obvious costs would be: salaries of military and civilian personnel, cost of utilities, maintenance on the building and grounds, maintenance on radio equipment, and general administrative costs. But what about other

costs? For example, there would be training costs for both military and civilian personnel, lost service time to the Navy due to travel and proceed time in connection with orders, computed retirement pay of both military and civilian personnel, cost of maintaining a supply system to support the station, construction and modernization costs amortized over a five-, 10-, or 20-year period. These are all valid costs that have to be included, but to do so on a fair and equitable basis would be difficult indeed. To carry the example a little further, political situations and instability with foreign countries must be considered. What about an overseas station? How are expensive moving and cost of living allowances to be figured in? What about currency revaluations and the balance of payments problem for foreign employees and American families living overseas? What are the costs associated with supplying a station on foreign soil with the necessities of life in time of war as well as in peace? What is the cost of political instability in connection with an American NAVCOMSTA located on foreign soil? What special political situations may arise from such a situation? When a statement is made that it costs X dollars to run a communication station for one year, has the statement not created more questions than it has answered?

For reasons stated above, the author has elected to avoid precise statements of numerical estimates except in cases where little or no misinterpretation will occur.

B. RELIABILITY

For the purpose of this thesis, reliability pertains to RIIXS hardware and the failure that may occur therefrom. Briefly defined, reliability will be considered the mean time between failures on system equipment under normal operations. RIIXS has three major areas critical to overall system reliability: CDCC, NFCIT, and the communication path between the two.

1. CDCC

Since everything in the world is relative, the most important part of an evaluation are the relative comparisons made with other "knowns" in the same area of operation. At the present time, there is nothing similar to the RIIXS Central Data Control Center in operation. The closest system that can be used for comparison is the now defunct Integrated Flagship Data System (IFDS) that had been aboard the USS Providence for approximately one year. IFDS was an R&D type ship/shore/ship data link system similar to the proposed RIIXS system. The major difference is that the computers, operating personnel, spare parts, display and other supporting EDP equipment were placed aboard the Providence. This is in contrast to RIIXS where the EDP-file system is placed ashore.

Computers that are placed aboard ship are placed in a hostile environment and therefore have to have additional military specifications that are normally

custom made to compensate for the unusual operating environment. They have to be designed to take the constant ship vibration, additional G-forces due to pitching and rolling, and occasional power shortages.

Based on the author's operational experience at sea and computer operation experience, the following assumptions appear reasonable. Dollar for dollar a computer system ashore could be built to have a higher system reliability than one placed aboard ship given a fixed computing power. Or, stated another way, any computer system that can be placed aboard ship should be capable of being duplicated ashore at either a lower price, a higher system capacity, a higher system reliability, or some combination of the three.

Experience with NTDS has shown that to achieve a certain level of system reliability, less sophisticated computers have to be used for shipboard systems as compared to shore-based systems. This is indicated by the use of second-generation computers aboard ships while third- and fourth-generation computers are used ashore. Therefore, it is reasonable to state that for the same level of sophistication, a higher reliability factor, as measured by mean time between failure, can be expected from shore-based computer systems as compared to shipboard systems.

2. NFCIT

The fleet commander's interrogation terminal aboard ship will consist mostly of unsophisticated electronic

equipment, the major exceptions being the minicomputer and visual display units. This equipment is small enough to allow for duplication to provide the desired reliability factor. The simplest piece of equipment will be a standard teletype that can be replaced by any one of the several that are normally found aboard large ships. Input/output terminals, high-speed printers, and modems are normally considered high reliability items with histories of proven shipboard operations.

3. Communication Path

The communication path between the CDCC and the NFCIT is the critical link in RIIXS. And since RIIXS is proposed as a subsystem to FLTSATCOM, the reliability of the communication path depends largely on the reliability of FLTSATCOM itself.

FLTSATCOM has been designed as a satellite communication system to be a quick follow-on to certain military R&D satellites such as TACSAT 1 and LES 6 [Ref. 12]. Therefore, it appears logical to compare reliability figures gained from these R&D satellites and COMSAT against reliability figures from current HF radio operations. Of course, the comparisons will not be exactly fair to the satellite system because HF holds the advantage in total dollars spent on R&D, modification expenditures, length of time in fleet operational experience, and redundancy of equipment. Nevertheless, some general comparisons can be made here.

COMSAT has found, and with very few exceptions, that once a satellite is placed into orbit, it will either work perfectly for its designed life period or it will not work at all. That is to say that once a satellite has started functioning properly, it will continue to do so for a period approximating its designed life period. On the other hand, if the satellite fails to start functioning properly within six months after launch, it probably never will. With very few exceptions, the military has had the same experience with its satellites.

HF radio communications is not quite this cut and dry. A particular radio path may exist between two users at one time of the day and may not exist at the same time the next day. Both users have to be continually searching the frequency spectrum to obtain a continuous HF radio link. If both users are mobile, the situation gets worse, and establishing a continuous HF radio link becomes much more difficult.

The concept of RIIXS is based on a reliable communication link between a mobile terminal at sea and some type of data file ashore. To date, a great preponderance of information indicates that HF radio cannot be used to transmit digital information over large distances in a continuous and reliable manner as required by RIIXS.

Current COMSAT operations have shown that digital communications are very reliable in the SHF spectrum using

communication satellites as the relay station between a large number of users separated by thousands of miles.

Until recently, it was thought that FLTSATCOM operating in the UHF spectrum would enjoy the same reliability factor between users. But recent tests involving TACSAT 1 have indicated that UHF signals are affected by ionospheric scintillation. The final results of the tests have not been published yet, but it does appear that scintillation effects are more significant than originally thought. A preliminary report on the tests indicates that scintillation effects are a result of at least seven variables:

Frequency of transmission
Time of sunspot cycle
Time of year
Time of day
Receiver latitude
Receiver longitude
Sight elevation angle to the satellite

Under worst-case situations, scintillation effects can cause power fades as high as 6 db to 12 db; however, power fades this serious were not found to last longer than five or six seconds [Ref. 5]. It should be noted that under similar worst-case situations of sunspot activity, time of day, and time of year that HF radio communications over distances greater than 500 miles would also suffer serious transmission effects.

C. SURVIVABILITY

The survivability of the RIIXS communication path is a very critical factor to the overall system. For the purpose of this thesis, survivability is considered the ability of a system to withstand hostile enemy action. In this way, a clear distinction can be made between survivability and reliability.

Communication satellites have received a great deal of criticism because of the apparent ease with which they can be neutralized. This fact is basically true of FLTSATCOM when analyzing the four satellites by themselves. However, compared to the complete Naval Communication System (NCS) and all its redundant communication stations, the facts look a bit different. There are two ways to view the comparison. The first is to reduce the total number of NAVCOMSTA's to four to be on a par with the number of FLTSATCOM satellites or, second, to increase the number of satellites to 23 to be on a par with the number of NAVCOMSTA's.

If it were possible to accurately calculate the cost of reconstructing all 23 NAVCOMSTA's and figure annual operating costs for five years, the total cost would probably not vary significantly from the cost of launching 23 communication satellites with a life span of five years each. Additionally, if information transfer capability and reliability factors were taken into account, the actual

amount of information transferred per dollar would probably prove to be less with the satellite system than with the HF system.[1] Until proven otherwise, the author will assume that a one-for-one exchange ratio between satellites and NAVCOMSTA's is reasonable in comparing the survivability of a satellite system to that of an HF system.

In order for a potential enemy to physically destroy a satellite he has to launch some type of space vehicle to accomplish the job. If this enemy wants to destroy all our satellites at the same time, then he has to launch at least as many space vehicles as we have satellites. Depending on the degree of success he desires, he may have to launch two or three space vehicles per satellite or else spend a great deal of money in making each one very sophisticated. Additionally, the enemy may want to destroy our satellites covertly vice overtly, further complicating his problem and adding even more time and expense to his project. Depending on the methods the enemy uses to destroy the satellites, he probably will be forced to expend as many dollars to destroy the satellites as it would cost to build and launch them.

As far as a NAVCOMSTA is concerned, there are numerous ways in which they could be rendered useless by an enemy force, and a majority of them would involve expenses substantially less than the cost of a space vehicle.

---

[1]This statement is the author's conjecture based on his own communications experience.

As an example, it would not be very difficult to cut the underwater cables connecting Hawaii and Guam by covert means. Destruction of CONUS NAVCOMSTA's would probably be more dramatic, but also could be accomplished by covert means. If American citizens voluntarily blow up banks, it seems more than reasonable that a financial reward would motivate them to render useless several of the more important communication stations in CONUS. NAVCOMSTA's located on foreign territory always risk the potential of damage by disgruntled nationals. It is reasonable to assume that a dedicated group of personnel, financed with several million dollars could knock out every NAVCOMSTA in the world within a few minutes of each other using conventional weapons.

The second major fault of satellites is the ease with which they can be jammed. This statement must be qualified because it is possible to provide satellites with certain anti-jam features. At the present, these features are expensive and tend to reduce the overall information exchange capacity of the satellite. But it is expected that advances in technology will tend to eliminate these drawbacks within the foreseeable future.

In order to jam a satellite, the enemy has to make a certain investment in a ground station with enough transmitting power to overpower the desired incoming signal from U.S. forces. Also, it is impossible to accidentally

jam a communication satellite; this means national policy could state that any attempts at jamming U.S. satellites would be taken as an act of hostility.

Jamming of HF radio signals would generally take more assets than jamming a comparable number of satellites. But it would be possible to "legally" jam HF radio without being considered an act of war in terms of contemporary standards.

Two very simple and inexpensive methods could be employed for HF jamming. The first would be to drop large amounts of chaff over certain land masses or oceans. The end result would be to neutralize certain American forces by eliminating their communication capability. Or the enemy may want to conceal his own operations behind a protective wall of chaff. The second means that could be employed would simply be for the enemy to transmit his routine messages in the U.S. military frequency spectrum. Although all of the U.S. messages would not be jammed, a substantial number would be rendered useless.

An added feature to the satellite system would seriously complicate the enemy's solution to physical destruction of the satellite. This feature would be the addition of three specially synchronized satellites; these three satellites would be in a synchronous orbit, but not a geostationary orbit. That is to say they would be launched so as to be initially synchronized at a point 40 degrees north of the

Equator. Due to the Earth's rotation about an inclined axis, the satellite would tend to migrate between 40° north latitude and 40° south latitude without any significant east-west movement. Because the Earth is revolving around the sun as well as rotating about its own axis, these satellites would make the north-south-north round trip travel in slightly under 24 hours. The north-south movement of the satellites will create additional tracking problems for receiver stations, and is serious enough to make the tracking solution cost-effective only on the Navy's largest ships. Again, however, this feature would increase survivability of the overall satellite system, and naval units in the polar regions would now be capable of exchanging information through satellites. (FTSATCOM is currently planned without any capability to operate in the polar regions.)

A great deal more information is available on the survivability of communication satellites from numerous Department of Defense agencies. Therefore, the author feels that it is not necessary to discuss the situation any further. In concluding this section on survivability, it becomes apparent that when compared on an equal scale, communication satellites offer many benefits not enjoyed by HF radio in the world of survivability.

D. MAINTAINABILITY

Maintainability of RIIXS is a major factor contributing to the overall performance of the system. Poor maintenance

procedures would seriously jeopardize system effectiveness. The major question at hand is whether it is easier to provide maintenance for an EDP data file system located aboard ship or for one located ashore.

As was pointed out earlier, computers that are located aboard ships have to be built to strict military specifications. Also, they are normally tailor-made to perform a specialized job. Therefore, any maintenance that was performed on the system would have to be accomplished by personnel specially trained for that system. Also, the parts and some of the test equipment required for the system would be specially designed for the system concerned. Computer software as well as hardware would fall into this same category.

Shipboard storage space for specialized computer system parts is severely limited on Navy ships. In addition, all spare parts stored aboard ship would be subject to accelerated deterioration due to vibration, humidity and G-forces that are not normally associated with shore storage spaces. To maintain a shipboard EDP system, the naval supply system will have to inventory thousands of specialized computer parts around the world.

As an example, if a part were to go bad that was vital to one of the onboard computers, the following might happen: First, the ship's supply center would be searched; failing there, the closest supply ship would be searched; failing

there, the closest supply center would be notified to supply the part; failing again, the requisition would be forwarded to a supply center in CONUS. It might take as long as several days to locate the proper replacement part and several more to retrieve it from the supply system. Of course, this whole example was based on the assumption that working test equipment was available to detect the malfunctioning part in the first place.

By placing the computers and EDP file system ashore, the maintenance problem should be greatly simplified. First of all, the shore-based system will be composed of standard factory equipment. This in itself is very beneficial. Not only will standard spare parts be readily available, but individual part failure may be detected sooner due to greater operating experience of similar system components.

A system ashore has a variety of maintenance options available. Maintenance performed by experienced factory trained personnel has very obvious advantages over maintenance performed at sea. This fact, coupled with the increased supply of spare parts and factory support, leads to the obvious conclusion that maintainability of a shore-based EDP system will have distinct advantages over a shipboard EDP system.

E. PERSONNEL MANNING

Historically, the Navy has always been concerned with the problems of having enough qualified personnel to operate its weapons systems. It is obvious that highly trained personnel are required to operate the increasingly sophisticated "support" systems as well as the weapons systems themselves. The increasing reliance on EDP equipment for automation and modernization within the Navy has caused a tremendous demand for qualified personnel. Communications systems are certainly no exception to the trend. There is no denying the fact that personnel qualified in the area of EDP will be paramount to the success of any communication system.

The author contends that by maintaining the data base ashore, as proposed by RIIXS, personnel manning problems will be greatly eased. As was described earlier, a great majority of the EDP equipment located at the CDCC will be standard off-the-shelf equipment without additional military specifications. This fact has three major beneficial points. First, the training of military personnel will be easily standardized throughout the Navy. Second, the training of military personnel could be contracted out to civilian organizations, or even computer manufacturers' schools. Thirdly, the personnel manning level of the CDCC could be largely civilian rather than military. As an example, one can look at the personnel manning level of a similar

system--IFDS. According to classified project reports on IFDS, a substantial number of officer and enlisted personnel are required to operate the system. No indication was made of the use or attempted use of civilian personnel to operate the system. RIIXS, on the other hand, can be designed to operate almost entirely with civilian personnel, and only a handful of supervisory military personnel.

This philosophy has several advantages. First, the Navy does not have to invest large amounts of money into fixed training assets such as buildings and computer equipment. Because of this fact, the operational system can be modified and improved without requiring costly changes in training equipment. Second, EDP qualified personnel can spend more time in operational billets vice educational or training billets. As the Navy continues to reduce its size and cost of operation, it is important that valuable personnel serve in operational vice training billets. Third, casualties among qualified military personnel at sea represent a loss that cannot be easily replaced. Considering the large civilian pool of EDP qualified personnel in CONUS, an emergency manpower shortage does not appear likely. Additionally, civilian personnel will be employed under civil service, and hopefully more career oriented than current enlisted personnel at the rate of E-4 and below.

The author feels that it is appropriate to compare personnel manning levels of RIIXS to that of a NAVCOMSTA.

As an example, NAVCOMSTA, San Francisco has virtually replaced all military personnel with civilian personnel in the area of EDP operations. The reduced manpower turnover rate and increased experience with the equipment has increased both effectiveness and efficiency in this area. Therefore, it appears logical to assume that this same type of superior performance by civilian personnel can be expected in the operation of EDP equipment in the CDCC of RIIXS.

F. DATA TRANSMISSION RATES

The rate at which information can be entered into and retrieved from a data base depends on many factors: size, location, organization of files, and type of equipment used. Data transmission rates will be considered with the understanding of holding all variables constant except location of the data base. Of primary concern is whether to locate the data base aboard ship or in CONUS.

The speed at which information will be transmitted will be near the speed of light. Therefore, only the transmission path will affect the time it takes to transmit and receive information. In the case of synchronous communication satellites, this delay is approximately one-fourth of a second for a one-way transmission. Since the data base in question is neither voice-oriented nor real-time-oriented, this delay period is not a critical factor. In other words, it is assumed that a NFC will not mind waiting a half second

longer to receive information from a shore-located data base than from a ship-located data base.

Neglecting time delay then, the real question is how much information can be retrieved in a given time period. If the data base is located aboard ship, then the information exchange rate would be limited only by the mechanical device used to print the retrieved information. Currently, this would be in the neighborhood of 2000 words per minute for standard shipboard equipment. (It is difficult to imagine a need for a print speed greater than this to support a single NFC.)

The major drawback to the data base located aboard ship is the problem of updating the data base with current information. There are two major areas of concern here. First is the speed at which the data base could be updated, and secondly, the problem of correlation and validation.

Currently, the most reliable means of updating would be 75 and/or 100 word per minute radio teletype. For the size of the data base as described in chapter II, a great number of RTT's and corresponding HF channels would be required to satisfy the updating requirement.

The immense task of correlating and validating the information prior to entering it into the data file also proposes a problem. If this chore were accomplished prior to shore-ship transmission, then some type of headquarters similar to the CDCC would be required (just as in RIIXS). If the correlation was not accomplished prior to

transmission, then two different problems arise. First is that a much higher information transfer capacity will be required to transfer raw data vice correlated data, and second, the fact that both additional manpower and space would be required to correlate the data upon reception aboard ship.

If the data base is located ashore, then obviously the user is separated from his desired product by a very real barrier. The only way to overcome this barrier is through the use of a high-speed and very reliable means of exchanging information. Although at the present time no such system is available, FLTSATCOM will solve this problem in the not too distant future.

Assuming that FLTSATCOM is implemented according to plans, the same assets will be available to the NFC whether the data base is located ashore or aboard ship. This will give the NFC the ability to use a 2,400 bps digital data link for transferring information from point to point. The basic question then becomes whether more digital bits of information must be transferred to update a shipboard data base system as compared to digital bits of information transferred in response to a query from the NFC through RIIXS. The exact answer will be a command decision based on the value placed on the data base itself. The author feels that to answer this question now is above and beyond the scope of the thesis; and that it is only necessary to point out that this aspect should be considered by personnel responsible for building the system.

There appears to be little doubt that no matter where the data base is located, there will be major problems associated with reliable high-speed data transmission rates.

G. DOLLAR COST RESOURCE ALLOCATION

To say that it is possible to put an exact dollar cost on RIIXS at the present time is pushing the absurd. The two largest unknowns happen to affect the two largest dollar investments in the system. These two unknowns are: the degree of success reached by FLTSATCOM and the size and type of computer equipment needed to maintain the NFC's data base.

Without FLTSATCOM or a similar satellite system, RIIXS as proposed will not be possible. The high-speed digital data links provided by synchronous satellites are vital to the successful operation of RIIXS. Although RIIXS needs the assets provided by FLTSATCOM, the opposite is not true. Therefore, the development and implementation costs associated with FLTSATCOM cannot be credited against RIIXS.

Other than initial development costs, the three major cost areas are the NFCIT, CDCC, and personnel. The NFCIT should be less difficult and much less expensive to install aboard ship than IFDS. The lessons learned during the one-year operational experience with IFDS should be applicable

to RIIXS. The proposed equipment for the NFCIT and complete installation costs should be less than one and one half million dollars.[2]

The most expensive part of the whole RIIXS system will be the CDCC. The expenses here can be divided into two major areas. The first area is the physical building itself, and the second is the EDP equipment required to maintain the data base for the NFC.

The CDCC should be located in close proximity to a FLTSATCOM ground terminal to increase transmission security, reduce transmission losses, and reduce transmission costs. Initially, all FLTSATCOM ground terminals will be located at NAVCOMSTA's. This fact should help reduce initial construction costs by at least providing the real estate necessary to build the CDCC.

Construction of the building should be according to the protective specifications of an important communications center, such as a NAVCOMSTA. The communication path between the CDCC and the FLTSATCOM ground terminal can be adequately satisfied by conventional coaxial cable. The major concern will be in supplying security for the cable itself.

The EDP equipment within the CDCC will be the most expensive part of RIIXS. It is envisioned that at least

---

[2]This figure is an estimate by the author based on similar systems.

three computers will be required along with sophisticated peripheral and display equipment. A more complete list of equipment can be found in chapter II; it is estimated that the costs will be several million dollars. Although the costs appear high, the opportunity for total system savings are great when compared to the costs of constructing several floating CDCC's for all NFC's all the time.

Personnel costs are expected to be high and also to increase with time as wage rates increase. It is anticipated that no more than 10 or 12 persons will be required to operate the NFCIT while 25 or 30 will be required to operate the CDCC. All the personnel in the NFCIT will be military while only 20 or 30 per cent need to be in the CDCC. In the area of personnel manning and job description, the experience gained from IFDS should be drawn on heavily.

H. CONTRIBUTION TO COMMAND AND CONTROL

The concept of satellite communication, and RIIXS in particular, offer tremendous potentials for improving both the strategic and tactical aspects of command and control. No longer will ships be confined to certain designated routes for communication purposes. Traditional lines of communication no longer exist with the establishment of reliable satellite communications. Fleet commanders would have the opportunity to operate their fleets in areas chosen totally for military reasons vice communication purposes for the first time in all of naval history. Every

major campaign in the last thousand years, whether at sea or on land, had to operate along established lines of communication. Synchronous satellites provide the potential for an umbrella of communication assets around the world, and RIIXS provides the NFC with a mobile data base of up-to-date vital information.

In contrast, current Navy policy advertises the location of NFC's by allowing them to operate from World War II vintage cruisers. They even announce the NFC's coming and going by raising and lowering his flag. Such policy allows the NFC and, in particular, flagships to become relatively easy targets for enemy action. NFC's are given large staffs and volumes of paper work for support. Putting all this information together results in the designation of NFC's and/or their flagships as high value targets for enemy action. In the case of the American Navy, destruction of the flagship results in the destruction of a large amount of the NFC's decision making ability along with his ability to communicate his decisions and orders.

On the other hand, the concept of RIIXS allows every ship in the Navy with FLTSATCOM capability to become a potential flagship with command and control capability nearly equal to the original flagship capability. This is because RIIXS allows the NFC to maintain a data base of valuable information in a secure location in CONUS. This information can then be retrieved by any naval vessel with

FLTSATCOM capability. RIIXS once again allows every NFC to operate with the freedom of movement once enjoyed by Admiral Nelson and Commodore Perry.

Two very important facts arise from this newly acquired freedom: command mobility and rapid command assumption. Command mobility is interpreted as the ease with which a NFC can move throughout his area of command whether at sea or ashore. RIIXS will allow a NFC to travel incognito throughout his whole area of command with virtually 100 per cent of the command capability that he would have on his own flagship.

The enemy is now confronted with a high-value target that is also highly mobile and elusive. If the NFC's flagship is destroyed, his new flagship will be the closest ship with a FLTSATCOM and RIIXS capability. He can now carry out operations on a second ship much the same way Commodore Perry did in the Battle of Lake Erie.

Updating the situation to current times, we can examine what happened to the USS Newport News in 1972. A non-hostile explosion in the number two turret forced a potential fleet flagship to retire from the fleet for several months to undergo repairs. If the Newport News had been a fleet flagship then a great deal of information vital to the operation of the fleet would have been lost. (If not, then where is the justification for 25-year-old cruisers as flagships?) Had RIIXS been available at the

time, the fleet would hardly have missed the <u>Newport News</u>' departure as the fleet commander transferred to another ship and carried on operations nearly as before.

The second big factor is rapid command assumption. In the event of the death of the NFC, the next senior man in the fleet will be able to assume command faster and more decisively through satellite communications. Through RIIXS he will have virtually all the same informatin that his predecessor had even though their ships may be separated by many miles. This ability of rapid command assumption with near "complete information" of both a tactical and strategic nature is an extremely valuable asset.

For those naval officers who believe fighting ships will be around for some time to come, they should review the Battle of Jutland. Admiral Jellicoe was unable to direct a vastly superior naval force into a decisive battle against the smaller German naval force because of his lack of control. He had command of his forces but he lacked control of the situation due to poor (or no) communications with the various elements of his force. He narrowly missed the opportunity to completely annihilate the German naval force and possibly to shorten World War I by one or two years as a result of poor communications. If nothing else, the Battle of Jutland is a dramatic example of how reliable communications can tremendously affect command and control at sea.

IV. CONCLUSIONS

The Remote Interrogation Information Exchange System concept is based on the premise that future NFC's will need a data processing system to assist them in decision making. The necessity for such an EDP system with a large data base was presented in chapter I. It was shown that the NFC's sphere of influence has grown enormously, yet the time within which the NFC must make tactical decisions has been reduced substantially. Additional factors that bear heavily on the NFC are "volatile political situations" and nuclear weapons capable of annihilating large portions of his fleet with little or no warning.

In today's complex world, neither the NFC nor his staff is capable of committing to memory all the vital items of information required for accurate and timely decisions. Therefore, recording and filing systems will be a requirement for the NFC of the future.

Approaches to this problem are clouded by the more encumbering questions of where to put the data-file system. Only two choices are really available: located remotely from the NFC or in close proximity to him. RIIXS resolves this question quite convincingly with the arguments presented in chapter III. It is envisioned that the data-file system of RIIXS would be large enough to require the use of large

electronic computers to organize, update, and retrieve information from the data base.

Seven basic criteria were used to compare such a system located aboard ship with one remotely located ashore. The seven areas are: reliability, survivability, maintainability, data transmission rates, personnel manning levels, dollar cost resource allocation, and contribution to command and control. In all but one, the RIIXS concept of placing an EDP system ashore was superior to the alternative shipboard system. RIIXS is a complete system concept using the advantages of shore-based computers with the ability to transfer vital information to the NFC through the use of FLTSATCOM satellites.

A brief summary of the evaluation criteria demonstrates that RIIXS is far superior to any data-file system yet proposed in the support of NFC's. In the area of reliability, RIIXS is vastly superior to an EDP system located aboard ship for several reasons. First, computers located aboard ships operate in a hostile environment. This means costly additional design features and/or reduced computing capability. Second, the availability of spare parts is severely limited by the storage space aboard ships. All factors of supply greatly favor a computer system located ashore vice one located at sea. Third, both the level of competence and number of personnel available to provide maintenance are more plentiful ashore than at sea.

The survivability of RIIXS is dependent mainly on the ability of FLTSATCOM to survive hostile enemy action. Russia is the only country with either the capability or the desire to destroy orbiting satellites for at least the next ten years, but the same is not true of a naval vessel carrying a computer system. Any of a large number of potential enemies, or even elements of nature, are capable of destroying the effectiveness of a ship-based computer system. If, for no other reasons than the fact that ships catch fire, have internal explosions, and occasionally sink, the author feels that RIIXS has a higher degree of survivability than a shipboard computer system.

The ability to perform proper maintenance is crucial to the overall effectiveness of any system. A shipboard computer system suffers from some of the same problems listed under reliability: shortage of spare parts, shortage of qualified personnel, hostile operating environment, and specialized equipment. These four problem areas are nearly eliminated by the Central Data Control Center (CDCC) of RIIXS.

The personnel manning problems of a sophisticated computer system at sea are tremendous. The Navy is continually fighting the problem of maintaining adequate numbers of qualified personnel. The more sophisticated and more specialized the system, the more difficult the problem. RIIXS reduces this problem by placing the most complicated

part of the system ashore. In this way, factory-trained civilian personnel will be in large supply for both maintenance and operator positions.

The data transmission rate for RIIXS is the 2400 bps channels provided by FLTSATCOM. This rate is substantially faster than the conventional 100-word teletype used in HF communications; however, a very large number of messages will be sent using RIIXS. The major question for consideration is: Would more time be used answering queries through RIIXS at 2400 bps than would be used in updating an EDP data base using HF 100-word-per-minute teletype? Even if the answer were to be in favor of putting the computer system aboard ship, the other six areas greatly favor RIIXS and would overshadow this point.

Dollar cost resource allocation is a very difficult question because of "technical unknowns" and political implications. There should be little argument to the statement that it is cheaper to build a computer system ashore than to build one aboard ship. Two very dramatic examples of the costs involved with placing a computer system aboard ship are NTDS and IFDS.

The contributions of FLTSATCOM and RIIXS to naval command and control are as important and dynamic as has been the introduction of HF radio and the digital computer. FLTSATCOM has the potential to provide a worldwide umbrella of communication assets for naval vessels. RIIXS, in

effect, has the potential for providing the NFC with a mobile data base of up-to-date vital information.

The concept of RIIXS is a capability never before experienced by the Navy. Because of this, some naval officers may consider it a luxury. As a result of this research, however, it is believed that RIIXS is not a luxury but rather an integral part of command and control that should be incorporated into the naval structure as early as possible. Those officers who feel reliable communications are an expensive luxury should ask themselves about the Pueblo, the Liberty and the "EC-121."

For example, RIIXS could have provided an invaluable service during the "Pueblo incident." The RIIXS data base could have told what the USS Pueblo was, its mission, its speed, its armament, crew complement, and political implications surrounding it. The type and strength of North Korean land, sea and air forces in the area, and their order of battle would also have been available. Of monumental importance to the NFC would have been information about "friendly forces" and their commands available to assist the Pueblo. In addition, FLTSATCOM would have provided reliable and secure communications between the Pueblo and all commands concerned.

Certain personnel will argue that those circumstances, and in particular the "Pueblo incident," will not happen again. Therefore, there is no need to provide sophisticated

communication systems such as RIIXS and FLTSATCOM to aid command and control. There is only one way to guarantee that these incidents do not happen again and that is not to supply the enemy an American Navy with which to prey upon. If there is to be an American Navy to patrol the seas and protect the homeland, then it should have the tools to accomplish the job effectively and honorably.

An obscure and maybe overlooked adversary to reliable and secure communications is the naval bureaucracy itself. Naval organizations and commands are planned around established communication links. If there is a radical change to those communication links, a certain amount of change must be reflected in the existing naval command structure. Because of this, a certain amount of resistance to FLTSATCOM and RIIXS, in particular, will emanate from a resistance to change within the Navy itself.

RIIXS was not conceived as a static system to serve only one commander. It is both possible and desirable to expand RIIXS capabilities to lower levels of operational command. As an example, RIIXS could be implemented in several steps: Step one would be for the numbered fleet commanders; step two for the task force commanders; step three for the group commanders; step four would be for the unit commanders, and step five for the element commanders.

A great deal of argument will continue in favor of the various commanders being in personal control of their own private data bases of information. But it is not physically

or financially possible to supply all the various force commanders with private data bases and expect them all to perform as well as a single CDCC as described by RIIXS. Under the author's concept of RIIXS, the NFC will maintain operational control of RIIXS at all times.

A very important factor that should not be overlooked and certainly must be taken into account during the decision making process is that both FLTSATCOM and RIIXS have very real adaptations for civilian use. This is true both in the development stage and in the event of a general disarmament. FLTSATCOM and RIIXS have the ability to serve the nation both from a military and a civilian standpoint. This is not true for many of the multi-million dollar weapon systems currently under construction.

In less than five years, it will be possible to purchase and launch synchronous communication satellites for less than it now costs to purchase one F-14 with spare parts. These two military items may be equal in price, but they certainly are not equal in the service they can provide to the Navy or even the nation as a whole. Current cost figures indicate that it would be possible to completely implement FLTSATCOM for approximately the same costs as one additional F-14 squadron. When decisions like this have to be made by high-ranking officials, serious attention should be focused on the question: Do we need additional weapon systems, or do we need more support systems

to make our current weapons more effective? FLTSATCOM and RIIXS will make current weapon systems more effective!

BIBLIOGRAPHY

1. Chief of Naval Operations SOR 32-98 FLTSATCOM System (U), July 1972 (SECRET Document).

2. Chief of Naval Operations Technical Evaluation of IFDS (U), September 1970 (CONFIDENTIAL Document).

3. Chief of Naval Operations Installation/Implementation Plan for Ship/Shore/Ship Data Link (U), August 1970 (CONFIDENTIAL Document).

4. COMSAT Technical Review, Volume 1, Number 1, Fall 1971, COMSAT Corp., Washington, D.C.

5. Grinnell, Donald P., LCDR, USN, Deputy Commander Operational Fleet and Evaluation Force Pacific, Staff. Personal interview, January 12, 1973.

6. Johnson, Daniel E., LT, USN, Deputy Commander Operational Test and Evaluation Force Pacific, Staff. Personal interview, January 21, 1973.

7. Martin, James T., Future Developments in Telecommunications, Englewood Cliffs, New Jersey, Prentice-Hall, 1971.

8. Martin, James T., Teleprocessing Network Organization, Englewood Cliffs, New Jersey, Prentice-Hall, 1970.

9. Naval Electronics Laboratory Center, Integrated Flagship Data System (IFDS) (U), July 1969 (CONFIDENTIAL Document).

10. Ortwein, Norman R., Naval Electronics Laboratory Center, Code 1400. Personal interview, January 8-12, 1973.

11. Potter, E. B., and Nimitz, Chester W., Sea Power--A Naval History, Englewood Cliffs, New Jersey, Prentice Hall, 1960.

12. Rodgers, Gary U., Naval Electronics Laboratory Center, Code 1400. Personal interview, October 25, 1972, through March 3, 1973.

13. Schneidewind, Norman F., Naval Postgraduate School, Code 55 Ss. Personal interview, February 22, 1973.

14. Shearer, Richard T., Naval Electronics Laboratory Center, Code 1400. Personal Interview, January 11, 1973.

15. Shutters, Raymond E., Naval Electronics Laboratory Center, Code 1400. Personal interview, October 25, 1972, through March 16, 1973.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Documentation Center Cameron Station Alexandria, Virginia 22314	2
2.	Library, Code 0212 Naval Postgraduate School Monterey, California 93940	2
3.	Asst Professor James P. Hynes, Code 55 Hj Department of Operations Research and Administrative Sciences Naval Postgraduate School Monterey, California 93940	1
4.	Library, Code 55 Naval Postgraduate School Monterey, California 93940	1
5.	Commander, Naval Communications Command Headquarters, Code N15 4401 Massachusetts Avenue, NW Washington, D. C. 20390	1
6.	Commander, Naval Electronics Laboratory Center, Code 1400 San Diego, California 92152	3
7.	LT John C. Lawlor, Jr., USN c/o George H. Newberg 5806 Seaboard Avenue Jacksonville, Florida 32210	1

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

ORIGINATING ACTIVITY (Corporate author) Naval Postgraduate School Monterey, California 93940	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

REPORT TITLE

Remote Interrogation-Information Exchange System: A Technically Viable Aid to Naval Command and Control

DESCRIPTIVE NOTES (Type of report and, inclusive dates)

Master's Thesis; March 1973

AUTHOR(S) (First name, middle initial, last name)

John Conrad Lawlor, Jr.

REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1973	70	15

a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

0. DISTRIBUTION

1. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Naval Postgraduate School Monterey, California 93940

3. ABSTRACT

The concept of accessing a data base and EDP equipment located ashore from ships at sea is presented as a complete system entitled Remote Interrogation Information Exchange System (RIIXS). The system contains the following elements: a data base located ashore; an input/output terminal located aboard ship; and a digital data link, provided by FLTSATCOM, connecting the two. RIIXS is designed to supply the fleet commander with operational information vital to command and control in addition to providing command mobility and rapid command assumption. RIIXS is evaluated on the following criteria: reliability; survivability; maintainability; personnel manning; data transmission rates; dollar cost resource allocation; and contribution to command and control. RIIXS is shown to be vastly superior to a similar system located aboard ship.

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Communication satellites						
Information exchange system						
Command and Control (communications)						
Information retrieval						
EDP system (remote access)						

Remote interrogation information exchange system: a technically viable aid to naval command and control.

16 APR 75 23288
29 APR 76 24421

Thesis
L3185 Lawlor 143306
c.1
Remote interrogation information exchange system: a technically viable aid to naval command and control.